DEVELOPMENT, FUNCTIONALITY, AND CONSUMER ACCEPTANCE OF A NOVEL READY-TO-EAT LAMB LEG PRODUCT

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ABSTRACT

The objective was to determine an ideal formulation for maximal acceptability and functionality of a ready-to-eat lamb leg product, evaluated by sliceability, sensorial attributes, lipid oxidative stability (TBA), and consumer analysis. Lamb legs (n=160) underwent two aging treatments (21d and 42d) and one of four marinations (Control, American, Caribbean, or Moroccan). Sliceability and TBA were not affected by marination (P >0.05). Cook loss was affected by marination and aging (P<0.05). Marination by aging affected initial (IJ) and sustained juiciness (SJ), flavor intensity, and overall acceptability (P<0.05), but not IJ, SJ, or warmed-over flavor (P>0.05). Control was juiciest and most accepted while American had most intense flavor (21d). American was juiciest and had most intense flavor and acceptance (42d). Consumer analysis of flavor, overall acceptability, and willingness to purchase was affected by marination (P<0.05); American had the highest values for all attributes. Consumers most frequently ranked the American marination treatment as most liked.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

INTRODUCTION

More than ever, American families have become dual-income households, leaving less time available for meal preparation. With employment and leisure activities increasing, the Western world is constantly moving towards a faster-paced lifestyle that lessons the time available for meal preparation and decreases overall cooking time (Costa et al., 2007). Though families have less time to cook and prepare meals, they still desire to have an enjoyable eating experience.

The ability to fully prepare and cook quality meals has diminished and in some cases disappeared completely, as there is generally less time due to the demanding schedules of active American families. The concern of meal quality declining as meal preparation time declines gives rise to the demand of convenience foods. Convenience foods provide the option of creating an improved meal-time experience without having to put forth extensive time and/or effort into preparation and cooking.

American lamb is typically an underutilized protein source. Lamb competes with beef, pork, veal, and poultry as the protein portion of consumers' meals. Lamb appears to be widely available with over eighty-two thousand sheep producers in the United States, the majority of which are family-owned and operated; this is not translated to the meat counter (American Lamb, 2011a). In reality there are barriers to lamb being readily available to consumers. The beef industry has the ability to create a range of low cost products because of its production systems which allow beef to be sourced from feedlots, croplands, pasture,

Journal of Animal Science

and rangelands, while lamb is more limited because of declining wool prices; the lamb industry is only recently becoming focused on meat production rather than textiles (DAFF, 2011). The pork industry benefits from the fact that processed meat products are a large portion its industry in comparison to beef and lamb. Additionally, lamb consumers are typically focused on buying higher-quality, higher-priced cuts; also, the majority of consumption is concentrated within ethnically-driven markets (Jones, 2003). For these reasons, lamb consumption per capita in the United States has been consistently around or below 1% of overall red meat consumption for decades (USDA/ERS, 2011).

The goal of the research was to broaden the consumer market for lamb by utilizing a conventionally average-value lamb cut to create a fully cooked, highly palatable, and economical product in the form of a spiral-sliced, ready-to-eat (heat-serve), lamb leg portion. Specific objectives of the research were to determine a formulation combination that achieves maximal acceptability and functionality of a novel ready-to-eat lamb leg product; determine consumer appeal and acceptance of a novel ready-to-eat lamb leg product; and lastly, determine the projected marketability and willingness to purchase based on consumer acceptance of a novel ready-to-eat lamb leg product.

LITERATURE REVIEW

Value-Added and Convenience Foods

Dual-income households have become a prominent characteristic of American families. Americans shifting into a faster-paced lifestyle as well as the increasing amount of time families now spend on leisure activities both contribute to the decline in the time available left to prepare and cook meals (Eilert, 2005). Often the heads of households are too tired to spend much time or effort in evening meal preparation and are looking for ways to save time; consumers want to conserve time with household chores such as shopping, cooking, and cleaning (Harris and Shiptova, 2007). These factors lead to compromising food quality and placing convenience as a major priority. Helping resolve this dilemma is the role of value-added foods, specifically convenience foods as today's food industries and retailers are expanding and moving towards the convenience foods market (Geeroms, et al., 2008).

In a broad spectrum, value-added products are those that have had time, place and/or form utility to a commodity in order to meet the preferences of tastes of the consumer (Oregon State University, 2012a). Value-added food products are raw or pre-processed commodities with value that has been increased through addition of ingredients or processes, making them more attractive to the buyer. Value-added foods can also be improved by becoming more readily usable by the consumer, driven by customer needs and perceptions (Kansas State Research and Extension, 2012). There are endless methods of adding value to food products, a few of which include drying, freezing, irradiating, and fermenting (Oregon State University, 2012b). Methods such as these can also improve product marketability and convenience.

With the evolution of preservation, packaging, and freezing, consumers are now given a much wider variety and greater availability of convenience foods. In 1979, Traub and Odland defined convenience food items as those that are “fully or partially prepared in which significant preparation time, culinary skills,, or energy inputs have been transferred from the homemaker’s kitchen to the food processor and distributor”. Specific to meat products it is evident that grocers have increased the literal amount of space provided for convenience meat products. In 2002, 69% of self-service meat cases were occupied by fresh meat and poultry; declining to 63% two years later, suggesting the increase of convenience foods items within the market (Mize and Kelly, 2004). Supporting the recent growing interest in convenience meats, in a survey of 1200 consumers a 7% increase was seen in consumed heat-and-eat meat/poultry at least once a week from 2010 to 2011 (Roerink, 2011). Furthermore, Roerink also found there was a 6% increase regarding overall consumption of marinated meats.

Meat Consumption

Meat consumption in the United States has increased enormously over the decades. In 2009, total consumption per capita per year of red meat, poultry, and fish reached over 190 pounds (boneless, trimmed-weight equivalent), 40 pounds above the same category 50 years prior, an increase of 27% (USDA/ERS, 2011). Rising incomes, as well as the emerging of dual income households, are largely responsible for much of this increase (USDA, 2003). Increased production and availability are also considerable contributors.

Lamb Consumption. Lamb consumption has generally declined since the 1950’s and has consistently comprised of less than 1% of overall red meat consumption since 1975

(USDA/ERS, 2011). Recently the demand for lamb has increased 5.7% between 1997 and 2007 following its previous steady decline (Shiflett, et al., 2007). This decline is partially due to the fact that lamb meat was originally a by-product of the wool industry; as the demand for wool decreased after World War II because of lesser use by military service personnel, as did lamb and mutton consumption. Another contributor to the decline in lamb consumption is the negative bias created during the wartime era, with canned mutton largely consumed as a protein source by G.I.s., or Government Issue military service members, during the war. Canned mutton was sent overseas as a food staple and primary protein source for the military so once GIs were back stateside they had no desire to eat it again (Apple, 2006). As bias against lamb occurs primarily in the older generation, there is a great opportunity among the younger consumer market to improve the overall acceptance of this protein source.

One sector that is responsible for of a large amount of the lamb consumed in the United States is the ethnically-driven market. Ethnic populations are the basis for a great amount of lamb consumption on the east and west coasts of the United States (Jones, 2004). As a primary protein source, lamb is more typically found in those of African, Caribbean, Greek, Latin American, Middle Easterner, and Native American descent, with the latter four ethnic groups accounting for more consumption than the other ethnic populations (Geisler, 2011; Jones, 2004).

Though available year round, the largest consumption of lamb in the United States occurs during the spring holidays. Demand more than doubles with holidays such as Easter and Passover, further emphasizing that it is underutilized outside of the spring season

(American Lamb, 2011b). In actuality, most Americans do not eat lamb at all while others consume much more than the one pound average per capita for the nation (Jones, 2004). In the past lamb has been viewed as a lesser protein option, not valued as a quality protein source as with beef, pork and poultry; lamb demand declined as consumer income increased thus economists have deemed it an inferior meat product (Purcell, 1989). This correlation was found in countries with overall higher income, such as in the United States, with the direct opposite occurring in countries of generally lesser income (Shroeder, et al., 2001). Presently, consumer roles have changed; Shiflett, et al. (2007) determined that there is now a positive relationship between increased income and increased lamb consumption.

In a model created for the American Lamb Board, Shiflett, et al. (2007) determined that one of the several factors that can affect lamb demand is the price of substitute meats. Shiflett, et al. hypothesized that rising beef prices would increase lamb demand because lamb would become relatively more affordable on a cost per weight basis. Also, higher income families who buy more beef in particular tend to also buy higher-priced beef cuts, potentially increasing the likelihood for these consumers to also purchase higher-priced lamb cuts. Consumers of lamb tend to prefer cuts such as the leg and loin, leaving producers and processors struggling to sell the remaining cuts (Jones, 2004). Driven by consumer preference, the United States sheep industry also focuses on these high-value cuts for the domestic market rather than on market segmentation or export markets (Jones, 2004).

Meat Curing

Curing is a method of meat processing used widely today and began as early as 3,000 B.C., originally used solely as a method of preserving food (Romans, et al., 1994). Though initially used for preservation, modern meat curing serves a variety of purposes. Food safety, extended refrigeration shelf-life, flavor development, and color development are all impacted by curing. Basic curing ingredients include salt, sugar, and nitrate/nitrite, each greatly influencing flavor, color, food safety, and shelf-life. Sodium ascorbate, sodium erythorbate, and phosphates are also often used to aid in the curing process. The most significant difference with today's cured meat products, in comparison to those of the past, is not only the differences in functionality, but also flavor intensity and lower salt content (Aberle, et al., 2001).

Ingredient Inclusion. Incorporation of cure ingredients can be done via application to meat surface, adding them to a meat mixture or emulsion, submerging a meat product into a brine solution, or direct injection into the meat (National Center for Home Food Preservation, 2012). For whole muscle cuts, such as a roast rather than chunks and pieces of meat that can undergo cure application via mixing, submersion into a brine solution and/or brine injection are common application methods. In a commercial setting, mechanized pumping is used to accomplish injection via stitch pumping (Romans, et al., 1994). The use of a multi-needle injector has been proven to be an effective method, with brine injected simultaneously and automatically through a series of hollow needles (Aberle, et al., 2001).

Salt. Salt is the most important curing ingredient and makes up the majority of the curing mixture because of its preservation and flavor attributes. Salt osmotically lowers the water content of the product thus functions as a dehydrator, limiting bacterial organisms to thrive and reproduce (Romans, et al. 1994). With salt, water is drawn out of the cell until it reaches the state where microorganisms cannot survive. Once applied, salt diffuses into the meat causing moisture to rise to the surface. Sodium chloride is the most commonly used salt in the meat industry because it has the most desirable flavor and is the most readily available. At high concentrations salt can promote the formation of a disagreeable gray color with some meat. To combat this, nitrites function as a means of developing the desirable pink cured color, explained in detail further in the nitrite ingredient section (National Center for Home Food Preservation. 2012).

Sugar. Though it does have a minor impact on flavor enhancement, when applied in cured meat products sugar is used primarily to counteract the harshness of salt. Sugar additionally provides the substrate for acid formation, lowering the pH of the cure (Romans, et al., 1994). It can also enhance the growth of microorganisms that enhance the reduction of nitrate to nitrite. In long curing processes, sugar serves as nutrient source for the flavor-producing bacteria of meat (National Center for Home Food Preservation, 2012). The most frequently used sugars in meat curing are sucrose and dextrose.

Nitrates/Nitrites. Sodium nitrate was originally discovered as an impurity in salt and has since been used for thousands of years to cure meat. During the curing reaction, nitrate is converted to nitrite, the active agent, which is used more commonly today in processed meats. The loss of an oxygen atom from a nitrate molecule causes this reduction (Nelson and Cox, 2008).

The four primary functions of nitrate and nitrite used in cured meat products are to provide aggressive bacteriostatic properties, act as a powerful antioxidant, improve flavor, and to develop the characteristic pink cured-meat color. With more than 700 substances having been tested as potential substitutions, nitrite is currently the only approved available additive that can complex iron, stabilize flavor, and produce the desired pink cured color, (Romans, et al., 1994). Essentially the most important function of curing meat is the reassurance of microbiological safety, put forth by nitrite addition. Nitrite is known to be the leading anti-botulinum agent in preventing botulism food poisoning, affecting the human nervous system. *Clostridium botulinum*, a gram-positive, anaerobic, spore-forming, rod-shaped bacterium, is able to grow under relatively thermophilic conditions (Romans, et al., 1994). Sodium nitrite effectively inhibits the growth of *C. botulinum* spores thus preventing botulinal toxin formation at appropriate levels of inclusion (Hustad, et al., 1973).

Nitrite is also a powerful antioxidant, inhibiting the oxidation of lipids in meat thus preventing the development of oxidative rancidity (Romans, et al., 1994). A characteristic warmed-over and stale flavor can be prevalent in cured meat products that do not contain this ingredient. Warmed-over flavor is caused by volatiles produced by oxidation of unsaturated fatty acids in meat. Formation of nitrosylhemochromogen immobilizes iron, hindering its catalytic activity, thus limiting the initiation of lipid oxidation (Aberle, et al., 2001). Nitrosylhemochromogen, a heat-stable pigment, does not undergo further color change with additional cooking of cured meat though the actual pigments of meat can change color. Upon its addition, nitrite will eventually reduce to nitric oxide. Nitric oxide has a greater affinity than water to the sixth binding site of the heme group of myoglobin, thus it is readily converted to nitrosomyoglobin (Romans, et al., 1994). Denaturation of nitrosomyoglobin stabilizes the bond between nitric oxide and the heme group, resulting in the pigment nitrosohemochrome (Vieira, 1996). This pigment is responsible for the typical bright pink color associated with cured meat. The stability of this pigment is easily influenced by oxygen, tension, light, and other factors. The desired bright pink color fades when exposed to light and oxygen; vacuum packaging is often used to combat oxidation of meat products (Aberle, et al., 2001).

There is controversy regarding the use of nitrite because of its toxicity if consumed in excessive amounts. There is stringent regulation of its use, with allowable levels being twenty to forty times below the dosage considered to be lethal (Aberle, et al., 2001). Another matter is the formation of nitrosamines, a carcinogenic compound that can occur under very high temperature or low pH conditions. As it is not likely to occur, the benefits of nitrite use far outweigh the risks.

Sodium Ascorbate and Erythorbate. Ascorbic acid, or vitamin C, and erythorbic acid and their salts have proven to accelerate the curing process by speeding up the curing reaction and color development. These optical isomers reduce nitrates and nitrites to nitric oxide more quickly. Additionally, sodium ascorbate and erythorbate are both used to stabilize the color of meat once cured because of their presence in residual amounts on the finished product. They are also beneficial as they inhibit the over-formation of nitrosamines (Romans, et al., 1994).

Phosphates. The primary purpose for adding phosphates to cured products is to increase the water-holding capacity of meat (Aberle, et al., 2001). Thus, there is less moisture loss during the cooking process, leading to a more tender and juicy final product. Product yield also increases with the increase of water-holding capacity, as well as increased brine retention (Ray, 2012). Using alkaline phosphates in cured meat products combats the amount of shrinkage that occurs during the smoking process (Romans, et al., 1994). Phosphates are only to be used when a liquid inclusion of the cure is utilized. Furthermore, phosphates help to provide a more acceptable, uniform, and stable cured meat color because of the reduced pigment oxidation and the decline of light reflection off of highly hydrated proteins. Phosphates also provide a defense against rancidity and browning during storage (Aberle, et al., 2001).

Sensory

Food patterns and degree of consumption are rooted largely in a person's culture (Hoogland, et al., 2005). Beyond this evidence are further attributes as to why consumers eat meat. People consume meat for tradition, nutritive value, availability, wholesomeness, variety, satiety value, and social or religious custom (Aberle, et al., 2001). Meat value is primarily based on its extent of acceptability to consumers. Satisfactory meat consumption depends on a variety of items that dictate an individual's sensory and psychological responses. Appearance, purchase price, aroma during cooking, cooking losses, ease of preparation for serving, edible portion available, tenderness, juiciness, flavor, and perceived nutritive value are a few of the many attributes that determine a person's reactions to a food (Aberle, et al., 2001).

Sensorial panel analysis, based on color and palatability attributes, is a method used to gauge consumer acceptability of a meat product. Palatability is described as the attributing characteristics of tenderness, flavor, and juiciness. The aforementioned qualities are rated by consumer in order of acceptance, respectively, when measuring overall palatability (Huffman, et al., 1996). Meat tenderness is primarily influenced by composition, skeletal muscle structure organization, as well as muscle integrity. Myofibril proteins and connective tissue are largely responsible for toughness when present in meat products. Meat product flavor is the second-most impacting palatability attribute. Heat application to meat develops characteristic flavor, depending on the degree and proportion of the fundamental compounds available. Water, protein, lipids, carbohydrates, minerals, and vitamins are the constituents of meat. Protein, lipids, and carbohydrates function as the primary players in flavor development because of their heat-activated compounds (Brewer, 2006). Color is the final essential factor that influences palatability. This attribute has the potential for having a positive or negative influence upon acceptability. Animal maturity impacts lean color based on their direct relationship. As described by Faustman, et al. (1996), animal maturity impacts lean color as concentrations of myoglobin are elevated with age. The heme protein present in myoglobin, which is responsible for meat tissue color, causes muscle to appear darker with increased age, thus affecting consumer acceptance of a product. A meat product's appeal directly correlates with the decline of its characteristic color that is ideal in a retail setting (Cross, et al., 1978).

Shelf-Life Stabilization

The function of modern meat-curing and smoking practices are to improve food safety, refrigerated shelf-life extension, and both internal and external flavor development (Aberle, et al., 2001). Prior to the use of mechanical refrigeration, curing was the principle means of meat preservation. Cured meat products were originally prepared with high amounts of salt for this purpose (Aberle, et al., 2001). Microbial growth requires a specified amount of water defined in terms of water activity (A_w). This amount can be reduced by removing the water present or with the addition of solutes to make the water unavailable to microorganisms. Most spoilage organisms require an A_w of 0.90 or greater for growth.

Fresh meat has an A_w of 0.99 or higher, providing an ideal environment for growth (Romans, et al., 1994). Lowering the A_w of meat products combats the possibility of microbial growth. Meat curing utilizes the addition of salt thus taking care of this issue.

Stabilization of shelf-life is also secured by meat smoking. The smoking of meat is defined as the process of exposing products to wood smoke as some point during manufacture (Aberle, et al., 2001). Heat processing, often occurring simultaneously with smoking, provides an additional means to control microbial growth. Reaching a specified temperature can kill microorganisms that may be present. Extending the duration of heat application on the product, thus the holding temperature, is more vital than simply reaching a certain temperature. Reaching an internal temperature of 65°C to 77°C (150°F to 170°F), or any temperature-time requirement as specified by Appendix A, is sufficient to kill most of the microorganisms that may be present (Aberle, et al., 2001; FSIS, 1999).

It is widely recognized that consumers are willing to spend more money to buy convenience and reduce meal preparation times as their incomes rise. Not only would consumers like to have ready-to-cook and/or eat foods, but would also appreciate and be willing to pay for already-marinated and seasoned foods (Shiflett, et al., 2007). Being that people that consume lamb prefer cuts such as the leg (Jones, 2004), here lies an opportunity for convenience to be added to a lamb product. The development of a pre-seasoned and/or marinated ready-to-eat lamb product would appeal to a convenience food-driven consumer market, as well as provide another outlet for the lamb industry.

MATERIALS AND METHODS

The research was completed within the Angelo State University Food Safety and Product Development Laboratory (FSPD), with consumer analysis taking place in retail markets within two Texas urban environments.

Treatments

Frozen lamb legs (n = 160), North America Meat Purveyors (NAMP) 233A, from a commercial abattoir were received frozen from frozen (3°C) storage at the FSPD for further processing; the legs were from two different harvest dates, one of which being 69 days postmortem (PM) and the second 6 days PM. Lamb legs were immediately thawed for 36 hours prior to fabrication. The 233A lamb legs were all of the animals' left hindquarter, and fabricated into NAMP 233E (a lamb leg with the aitch bone and shank removed to the heel), commercially known as a steamship leg. They were then randomly assigned to one of four treatments (n = 40/treatment) and marinated utilizing both multi-needle injection and vacuum tumbling. Legs from each harvest date were evenly distributed across all treatments. The legs were pumped to 10% of their green weight with a multi-needle injector (KOCH günter pökelinjektor – Kansas City, MO). Specific treatment seasoning blends were added during vacuum-tumbling (KOCH LT-15 – Kansas City, MO) for 30 minutes at -10 mm Hg and 12 RPM. The four treatments were then placed in separate containers in a cover pickle (50% of original concentration by addition of water) for 16 hours at less than 38°F. All treatments included a base brine of water, salt, dextrose, sodium phosphate, and sodium erythorbate (Table 1). Three treatments had the addition of one of three seasoning blends: American, Caribbean, or Moroccan (Table 2). The final salinity of the injection brine was 66° with the final cover brine having a salinity of 33°.

The American seasoning blend consisted of pepper, garlic, and onion. The Caribbean seasoning blend consisted of thyme, cinnamon, nutmeg, all spice, red pepper, onion, and turmeric. The Moroccan seasoning blend consisted of pepper, garlic, onion, rosemary, turmeric, paprika, coriander, and cumin. After marination in the cover brine, the lamb legs were smoked (Alkar 700 HP – Lodi, WI) following a standard smokehouse cycle and cooked to a minimum internal temperature of 65.5°C (150°F), as shown in Table 3. Once smoking was complete, the lamb legs were chilled to an internal temperature between 0.5-3.3°C (33-38°F), ideal slicing temperature, within 4 hours. The lamb legs were then sliced using a Spirocutter T-2000 (Spirocut Equipment Co. – Fort Worth, TX) and vacuum-packaged for post-processing aging.

Sliceability

During the slicing process, sliceability was determined by selecting the centermost 5 cm-thick section and slicing it into as many 0.5 cm-thick slices as possible. This portion was selected to minimize variation across lamb legs. Sliceability was calculated as the percentage of intact slices of the total number of slices: % = 100 – (number of broken slices/total number of slices) x 100.

After slicing and packaging, legs were assigned to two aging periods (n = 20/treatment), for 21 and 42 days and stored at 4°C. At the end of the first aging interval (21 d) , lamb legs were removed from packaging and cut in half and further portioned as seen in

Figure 1. The aitch bone end of the lamb leg went into the 21 d aging treatment while the shank end of the lamb leg went into the 42 d aging treatment. Each half of the leg was serially cut into so that the centermost 2 inches was portioned for consumer analysis, the second 2 inches were portioned for sensory analysis, and the final endmost portion was used for thiobarbituric acid reactive substance assay (TBA) analysis. Lamb leg portions were frozen at -10°C until analysis.

Trained Sensory Analysis

Lamb leg portions were removed from frozen storage and thawed at 4°C 12 – 24 hours prior to sensory evaluation. Portions were reheated to an internal temperature of approximately 60°C in a convection oven at 325° F (Aberle, et al., 2001). Steaks were placed on an aluminum pan without coverage. To prevent analysis of dry surface samples, the top slice was removed from each portion. Once reheated the portions were cut into 1 x 2 cm pieces and stored in warming pans until served to trained panelists. All samples were served and analyzed by a trained sensory panel for initial and sustained juiciness, initial and sustained tenderness, flavor intensity, overall acceptability, and warmed-over flavor according to procedures outlined by Cross et al., (1978) as shown in Table 4.

Lipid Oxidative Stability

Lipid oxidative stability was determined utilizing a thiobarbituric acid analysis as detailed by Buege and Aust (1987); this analysis assisted in determining any deleterious effects on product quality and shelf-life potentially caused by the respective treatments. In brief, homogenate in 2 mL amounts was combined with 4 mL of trichloracetic/thiobarbituric acid reagent and 100 µL of 10% butylated hydroxyanisole. Samples were then incubated in a

99°C water bath for 15 minutes, allowed to cool in cold water for 10 minutes, and spun at 2000xG for 10 minutes. The absorbance of the supernatant was then read against a blank containing like reagents at 531 nm with a Thermo Scientific UV-Visible Evolution 201 spectrophotometer. A malonaldehyde standard, utilizing 1,1,3,3-tetraethoxypropane and thiobarbituric acid, was used and thiobarbituric acid substances were reported as mg/10g of meat.

Consumer Analysis

Consumer analysis consisted of a close to representative sample of the general population in Lubbock and San Angelo, Texas. One retail center (grocer) within San Angelo and two within Lubbock were used during this analysis. At least 7 consumers were surveyed per sample panel, with 16 sample panels conducted at each grocer for a total of over 112 consumer surveys at each store. Each consumer was asked to fill out demographic data including gender, ethnicity, age, household income, and the number of times they have consumed lamb within the last month. They then evaluated four samples, one of each of the four seasoning treatments. All samples from each panel were of the same aging treatment, panels were evenly distributed among each of the two aging treatments for analysis. Evaluations were based on flavor, overall acceptance, and their willingness to purchase (Figure 2). Consumers were instructed to make a vertical line or mark on each of the three scales, indicating their opinion of each of the samples; the far left signified extremely dislike and the far right signified extremely like. There were no anchor points on any of the scales. To collect the data, the distance from the beginning of the scale to the vertical line was measured in millimeters.

Statistical Analysis

Dependent variables included trained sensory, oxidative stability, sliceability, and consumer sensory attributes and was analyzed using a 4 X 2 factorial arrangement (4 marination treatments X 2 aging periods) with a completely randomized design. All data was analyzed using the mixed model (PROC MIXED) procedure of SAS (SAS Inst. Inc., Cary, NC) except for the consumer ranking data. Consumer ranking data was analyzed for frequency distribution (PROC FREQ) and chi square analysis. Spice blend, aging period, and interactions are the fixed effects and individual lamb leg roasts served as experimental units, with significant ($P \leq 0.05$) treatment means separated using Fisher's protected LSD.

RESULTS AND DISCUSSION

Sliceability

Sliceability was not affected ($P = 0.056$) by marination treatment (Table 5). As values ranged from 94.22% (Moroccan treatment) to 98.5% (Control treatment), sliceability was shown to be higher than that found in similar research. In a study by O'Neill, et. al, (2003) sliceability of standard processed hams was found to have an average sliceability of 77%. This may have been attributed to the pork hams being boned out prior to being processed while the lamb legs were not; lack of binding between pork ham muscles may have been contributing factor. Lamb also tends to be leaner in comparison to pork, thus the potential for higher protein binding between muscles (USDA, 2012a; USDA, 2012b).

Trained Sensory Analysis

Cook loss and trained sensory attribute scoring is shown in Tables 6 and 7. Cook loss was dependent on both marination treatment ($P < 0.001$) and aging treatment ($P < 0.001$), but not their interaction ($P = 0.19$). The American marination treatment had the least amount of cook loss with 11.77% while the Caribbean marination treatment had the most with 15.81%. Samples from the 21 d aging treatment had the higher cook loss value with 14.08% and the 42 d aging treatment had a value of 12.23%. This data corresponds with results from other studies finding that cook loss of lamb decreases with aging (Devine, et al., 2002a; Devine, et al., 2002b). This is a result of the structural changes that occur with denaturation of proteins, concurrent with aging (Offer and Knight, 1988).

Initial juiciness was affected by marination treatment ($P = 0.002$), aging treatment ($P < 0.001$), and marination treatment x aging treatment ($P = 0.01$). Within the 21 d treatment, Caribbean scored the lowest (5.17 ± 0.10), just over slight juiciness while the Control scored the highest (5.85 ± 0.10), approaching moderate juiciness. The Moroccan treatment had the lowest score (5.69 ± 0.10) of the 42 d treatment and the Control and American equally had the highest score (5.88 ± 0.10), again approaching moderate juiciness. Sustained juiciness was affected by marination treatment ($P = 0.02$), aging treatment ($P < 0.001$), and marination treatment x aging treatment ($P = 0.02$). Paralleling initial juiciness results of the 21 d treatment, the Caribbean treatment had the lowest value (5.55 ± 0.10) and the Control had the highest (6.16 ± 0.10). Similar to the 21 d initial juiciness, the 42 d Moroccan treatment scored the lowest (6.02 ± 0.11) but the American alone had the highest score (6.17 ± 0.10). As a score of 5 denotes the sample as slightly juicy and 6 as moderately juicy, a score of 5.85 (Control, 21 day aging) is closely approaching the threshold of moderate juiciness initially, and well exceeds this marker with sustained juiciness (6.16 ± 0.10). Likewise within the 42 day treatment, the Control and American treatments approach moderate juiciness then achieve this with sustained analysis (6.14 ± 0.10, 6.17 ± 0.10). Marination treatment ($P = 0.36$), aging treatment ($P = 0.29$), or their interaction ($P = 0.53$) did not affect initial tenderness. Sustained tenderness also was not affected by marination treatment ($P = 0.36$), aging treatment ($P = 0.39$), nor their interaction ($P = 0.38$). Tenderness values at least approached moderate tenderness though in most cases surpassed this threshold (Table 4). Flavor intensity was not affected by aging treatment ($P = 0.16$) but was affected by marination treatment ($P = 0.0046$) and marination treatment x aging treatment ($P = 0.03$). Overall, samples were scored as having slight to moderate flavor intensity. Within 21 d aging the Caribbean treatment scored the lowest (5.84 ± 0.10) and the American scored the highest (6.28 ± 0.10). Similarly, Caribbean again scored the lowest (6.25 ± 0.10) and the American treatment scored the highest (6.40 ± 0.10) of the 42 d treatment. Overall acceptability was not dependent on marination treatment (P = 0.16) but was dependent on aging treatment (P = 0.02), and marination x aging treatment (P = 0.02). Caribbean was scored the lowest (P = 5.67 ± 0.11) while Control scored the highest (P = 6.23 ± 0.11). Warmed-over flavor was not affected by marination treatment (P = 0.62), aging treatment (P = 0.271), or marination x treatment (P = 0.80).

Consumers value palatability as the most important characteristic of meat products, as tenderness, juiciness, and flavor all affect their overall acceptance. It is important to note that with all sensory attributes, the Control and American scored the highest among all treatments. The highest initial juiciness values were 5.85 ± 0.10 (Control, 21 d) and 5.88 ± 0.10 (Control and American, 42 d), approaching the moderate juiciness. The highest sustained juiciness values within the treatments, 6.16 ± 0.10 (Control, 21 d) and 6.17 ± 0.10 (American, 42 d), indicate these treatments as moderately juicy. Control (6.05 ± 0.09, 21 d IT; 6.35 ±0.09, 21 d ST) and American (6.08 ± 0.09, 42 d IT; 6.37 ± 0.10, 42 d ST) treatments all fell within the scope of moderate tenderness among initial and sustained assessment. The American treatment within both aging treatments had moderate flavor intensity. The Control (21 d) and American (42 d) both were moderately liked, as well as had no apparent warmed-over flavor.

Lipid Oxidative Stability

Lipid oxidative stability values can be found in Table 8. Values were not dependent on marination treatment (*P* = 0.63), aging (*P* = 0.09) treatment, or their interaction (*P* = 0.63). There was a tendency for the aging treatment to effect TBA value, with the 21 d aging treatment having more oxidation (0.09 mg malonaldehyde/10g meat) than the 42 d (0.80 mg malonaldehyde/g meat) treatment. These values do not follow with results of other studies finding that that oxidation increases with aging time in raw lamb as well as with pork ham (Kerry, et al., 2000; Berruga, et al., 2005; and Dineen, et al., 2001). These results suggest that differences among ingredient inclusion into a ready-to-eat lamb leg product do not affect shelf-life.

Consumer Analysis

Consumer demographic data can be found in Table 9. Analysis of flavor, overall acceptability, and willingness to purchase by treatment and store is denoted in Tables 10 and 11, respectively. Consumer analysis of flavor was affected by marination treatment ($P <$ 0.001), but not by store (*P* = 0.11) or aging treatment (*P* = 0.72). Flavor was also not dependent on marination treatment x store (*P* = 0.82), marination treatment x aging treatment (*P* = 0.18), or marination treatment x store x aging treatment (*P* = 0.91). The scale for consumer opinion of these attributes was measured from 0 to 160 mm, 0 representing extreme dislike and 160 representing extreme like. A value of 80 represented a moderate opinion. The Caribbean treatment had the lowest value (99.67 ± 2.22) while the American had the highest (112.08 ± 2.22). Overall acceptability was dependent on marination (*P* = 0.0037) but not store (*P* = 0.13) or aging (*P* = 0.72). Additionally, marination x store (*P* = 0.94), marination x aging (*P* = 0.72), and marination x store x aging (*P* = 0.93) all did not affect overall acceptability. The Caribbean treatment had the lowest value (100.67± 2.24) and the American had the highest (111.94 ± 2.23). Consumers' willingness to purchase was affected by marination (P = 0.0043) and store (P = 0.01), but not aging treatment (P = 0.68). Furthermore, marination treatment x store (P = 0.76), marination x aging (P = 0.41), and marination x store x aging (P = 0.93) all did not have an effect on consumers' willingness to purchase. Consumers found the Caribbean samples to have the lowest willingness to purchase value (90.57 ± 2.78) and were most willing to purchase the American treatment (104.38 ± 2.77). Generally, consumers within the second store were the least willing to purchase (92.78 ± 2.36) a ready-to-eat lamb leg product while consumers within the third store were the most willing to purchase (103.35 ± 2.68), with the second store being within the middle (95.85 ± 2.15). This data may be more pertinent when determining a location to sell the final product.

Consumer rankings of the four marination treatments are shown in Table 10. When ranking the four samples, the American treatment held the majority as most liked (36.52%). The Control was ranked second (28.43%) for most liked, followed by the Moroccan (20.59%) then Caribbean (14.46%) treatments. Of the four rankings, the American treatment represented 62.9% between Rank 1 and Rank 2, further suggesting that this treatment was the most favored of the four.

IMPLICATIONS

Sliceability was not affected by the varying ingredient inclusions, and actually had higher sliceability in comparison to similar studies with pork hams. Sensory analysis revealed that initial and sustained tenderness as well as warmed-over flavor were not affected by marination or aging treatments. The Control and American treatments had the most juiciness among initial and sustained analysis ranging from slight to moderate juiciness. The American treatment had highest flavor intensity within both aging treatments, with samples having slight to moderate intensity. The Control had the highest overall acceptability score of the 21 d aging treatment, while the American had the highest score of the 42 d treatment, both of which being moderately liked. From this it can be determined that the Control and American treatments have the highest palatability. Consumer analysis illustrated the American treatment to have the highest measured value among all attributes (flavor, overall acceptability, and willingness to purchase). Consumers ranking indicated the American treatment to be the most liked. TBA values determined that further aging did not negatively affect lipid oxidative stability, a marker of shelf-life. Moreover, consumer analysis was not affected by aging and sensory analysis was only positively affected because of it.

CONCLUSION

Aging did not have a negative affect within the analyses. The American and Control treatments were proven to be the most palatable. Consumer analysis revealed that the American treatment was the most favored across all measured and ranked attributes, thus narrowing the ideal treatment to solely the American. Sliceability was demonstrated to be successful, thus an advantageous approach to further marketing a ready-to-eat lamb leg product. In conclusion the research suggests that a spiral-sliced lamb leg with an American-style seasoning blend, regardless of aging, has the potential to be a successful convenience food product in today’s consumer market. This product presents much versatility, as it could be utilized on a weekly basis as a protein staple yet could provide high profitability even if sold only during the holiday seasons.

The next phase for future research could entail nationwide consumer analysis, as the current research was limited in that it focused on only two urban environments within Texas. A specific price point would need to be determined as well. This research presented samples to both trained sensory panel and consumer analysis in the form of a reheated meat product. Additional research could be focused on its palatability and overall acceptance in a non-reheated state, potentially in the form of a lunch meat, similar to ham luncheon meats.

Table 1. Brine Formulation for Lamb Legs

Ingredients	Percent Weight
Water	79.80
Salt	10.95
Dextrose	2.75
Sodium Phosphate	2.75
Sodium Erythorbate	0.30
Sodium Nitrite	3.45

Table 2. Lamb Leg Treatments

Treatment Number	Seasoning
Control	Base Brine
1	Base Brine + American Seasoning Blend
2	Base Brine + Caribbean Seasoning Blend
3	Base Brine + Moroccan Seasoning Blend

Table 3. Smokehouse Cycle for Lamb Legs[a]

Step	Hr	Min	Dry bulb	Wet Bulb	Internal Temp	Smoke Preheat	Smoke Run	H2O Hum
1	0	45	38	24	0	ON		ON
2	0	45	43	32	0		ON	ON
3	1	0	54	49	0		ON	ON
4	1	0	60	43	0			ON
5	1	0	66	52	0		ON	ON
6	1	30	70	46	0			ON
7	2	0	77	49	66			ON

[a] all temperatures in °C

Table 4. Sensory Panel Scoring for Ready-To-Eat Lamb

Juiciness	Tenderness	Flavor Intensity
8 Extremely Juicy	8 Extremely Tender	8 Extremely Intense
7 Very Juicy	7 Very Tender	7 Very Intense
6 Moderately Juicy	6 Moderately Tender	6 Moderately Intense
5 Slightly Juicy	5 Slightly Tender	5 Slightly Intense
4 Slightly Dry	4 Slightly tough	4 Slightly Bland
3 Moderately Dry	3 Moderately Tough	3 Moderately Bland
2 Very Dry	2 Very Tough	2 Very Bland
1 Extremely Dry	1 Extremely Tough	1 Extremely Bland

Warmed-Over Flavor	Overall Acceptability
1 No Warmed-Over Flavor	8 Like Extremely
2 Slight Warmed-Over Flavor	7 Like Very Much
3 Moderate Warmed-Over Flavor	6 Like Moderately
4 Extreme Warmed-Over Flavor	5 Like Slightly
	4 Dislike Slightly
	3 Dislike Moderately
	2 Dislike Very Much
	1 Dislike Extremely

Table 5. LS Means ± SE of Sliceability of Marination Treatments of Lamb Legs (n=160)

Marination Treatment	Sliceability Value
Control	98.50 ± 1.17^{cd}
American	97.76 ± 1.18^{bd}
Caribbean	95.83 ± 1.17^{abc}
Moroccan	94.22 ± 1.26^{a}

^{abc}Values that lack common superscripts differ ($P \leq 0.05$)

Table 6. LS Means ± SE of Cook Loss of Lamb Legs by Marination Treatment and Aging Treatment (n=160)

Marination Treatment	Cook Loss
Control	12.16 ± 0.52^{bc}
American	11.77 ± 0.52^{ac}
Caribbean	15.81 ± 0.52
Moroccan	12.86 ± 0.52^{ab}
Aging Treatment^{d}	Cook Loss
21 d	14.08 ± 0.37
42 d	12.23 ± 0.37

^{abc}Values within marination treatment that lack common superscripts differ ($P \leq 0.05$)
^{d}Values within aging treatment that lack common superscripts differ ($P \leq 0.05$)

Table 7. LS Means ± SE of Sensory Attributes of Aging and Marination Treatments (n=160)

Aging Treatment	Marination Treatment	IJ	SJ	IT	ST	FI	OA	WOF
21 day	Control	5.85 ± 0.10^{bc}	6.16 ± 0.10^{c}	6.05 ± 0.09	6.35 ± 0.10	6.15 ± 0.10^{bc}	6.23 ± 0.11^{c}	1.03 ± 0.01
	American	5.45 ± 0.10^{ab}	5.74 ± 0.10^{ab}	5.93 ± 0.09	6.20 ± 0.10	6.28 ± 0.10^{ac}	5.92 ± 0.11^{ab}	1.03 ± 0.01
	Caribbean	5.17 ± 0.10	5.55 ± 0.10^{b}	5.86 ± 0.09	6.11 ± 0.10	5.84 ± 0.10	5.67 ± 0.11^{b}	1.02 ± 0.01
	Moroccan	5.60 ± 0.10^{ab}	5.90 ± 0.10^{ac}	6.06 ± 0.09	6.39 ± 0.10	6.26 ± 0.10^{bc}	6.07 ± 0.11^{ac}	1.02 ± 0.01
42 day	Control	5.88 ± 0.10	6.14 ± 0.10	5.98 ± 0.09	6.26 ± 0.10	6.00 ± 0.10^{d}	6.08 ± 0.11	1.03 ± 0.01
	American	5.88 ± 0.10	6.17 ± 0.10	6.08 ± 0.09	6.37 ± 0.10	6.40 ± 0.10^{bc}	6.19 ± 0.11	1.01 ± 0.01
	Caribbean	5.80 ± 0.10	6.10 ± 0.10	6.00 ± 0.09	6.30 ± 0.10	6.25 ± 0.10^{acd}	6.17 ± 0.11	1.01 ± 0.01
	Moroccan	5.69 ± 0.10	6.02 ± 0.11	6.11 ± 0.09	6.36 ± 0.10	6.27 ± 0.10^{ab}	6.17 ± 0.11	1.01 ± 0.01
P > F								
Trt		0.002	0.024	0.360	0.360	0.005	0.160	0.620
Age		<0.001	<0.001	0.300	0.390	0.160	0.020	0.270
Trt x Age		0.014	0.023	0.530	0.380	0.033	0.020	0.800

^{abcd}Values within an attribute in aging treatment in that lack common superscripts differ ($P \leq 0.05$)

Table 8. LS Means ± SE of Thiobarbituric Acid Analysis for Marination and Aging Treatments on Lamb Legs (n = 320)

Marination Treatment	mg malonaldehyde/10g meat
Control	0.86 ± 0.09^a
American	0.90 ± 0.09^a
Caribbean	0.79 ± 0.09^a
Moroccan	0.95 ± 0.09^a
Aging Treatment	
21 d	0.95 ± 0.06^a
42 d	0.80 ± 0.06^a

[a]TBA values within treatment that lack common superscripts differ ($P \leq 0.05$)

Table 9. Consumer Demographic Data (n=440).

Gender	%	Ethnicity	%	Age[a]	%	Income	%	Consumption[b]	%
Male	48.2	White (Non-Hispanic)	84.6	18-25	19.1	<$10k	8.3	0	79.4
Female	51.8	Black or African American	2.6	26-35	18.6	$10k-14,999	3.6	1	11.9
		Hispanic or Latino	10.2	36-45	14.1	$15k-24,999	6.7	2	3.0
		Asian	1.6	46-55	17.1	$25k-34,999	6.5	3	1.9
		Pacific Islander	0.3	56-65	18.8	$35k-49,999	14.0	≥4	3.8
		Native American or Alaska Native	0.3	66+	12.4	$50k-74,999	23.1		
		Other	0.3			$75k-99,999	14.8		
						>$99,999	23.1		

[a]Age in years

[b]Frequency of lamb consumption in the last month

Table 10. LS Means ± SE of Consumer Opinion of Lamb Legs based on Marination Treatment and Store (n=440)

		Flavor	Overall Acceptability	Willingness to Purchase
Treatment	Control	104.80 ± 2.22^{ac}	108.42 ± 2.24^{ac}	95.38 ± 2.78^{bc}
	American	112.08 ± 2.22^{b}	111.94 ± 2.23^{ab}	104.38 ± 2.77^{a}
	Caribbean	99.67 ± 2.22^{c}	100.67 ± 2.24	90.57 ± 2.78^{b}
	Moroccan	107.92 ± 2.22^{ab}	108.46 ± 2.23^{bc}	98.96 ± 2.78^{ac}
Store	1	105.52 ± 1.72^{ab}	105.93 ± 1.73	95.85 ± 2.15^{a}
	2	103.45 ± 1.89	105.42 ± 1.90	92.78 ± 2.36^{a}
	3	109.39 ± 2.14^{b}	110.77 ± 2.17	103.35 ± 2.68

Means within column that lack common superscripts differ ($P \leq .05$)

Table 11. Frequency of Consumer Ranking by Marination Treatment (n=440)

Marination Treatment	Rank 1		Rank 2		Rank 3		Rank 4	
	Consumers	%	Consumers	%	Consumers	%	Consumers	%
Control	116	28.43	103	25.62	61	15.25	124	30.77
American	149	36.52	106	26.37	83	20.75	65	16.13
Caribbean	59	14.46	88	21.89	149	37.25	104	25.81
Moroccan	84	20.59	105	26.12	107	26.75	110	27.30

Figure 1. Analyses Portioning of Lamb Legs

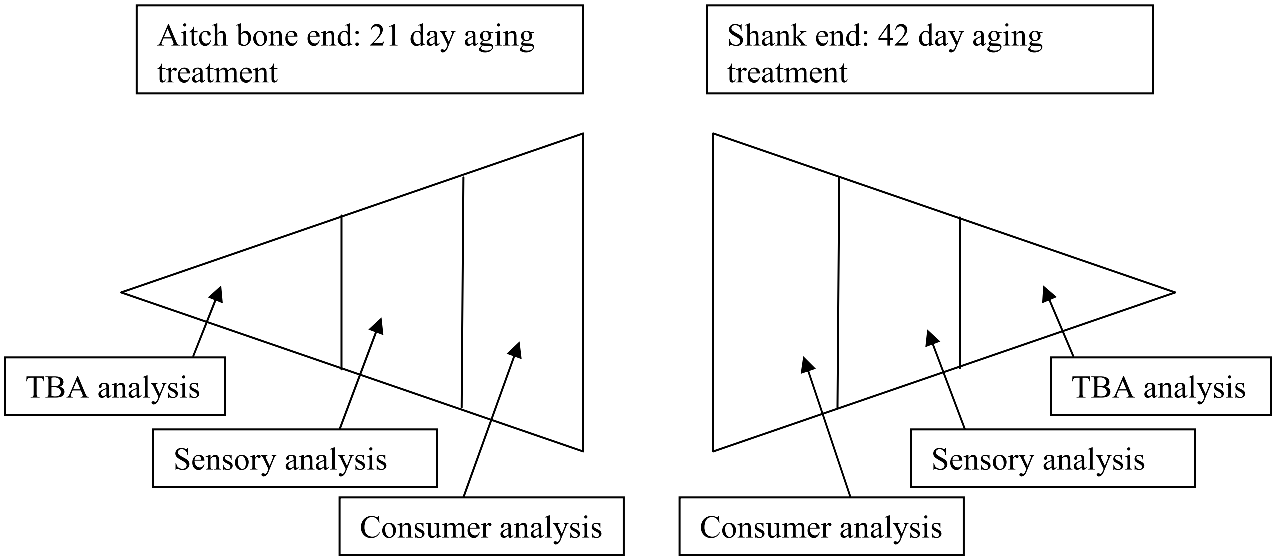

Figure 2. Consumer Analysis Survey

Please circle the appropriate response

Gender:	Male	Female	**Ethnicity:**	White (Not Hispanic)	Black or African American	Hispanic or Latino	Asian	Pacific Islander	Native American or Alaska Native	Other

Age:	18-25	26-35	36-45	46-55	56-65	66+

Household Income	<10,000	10,000-14,999	15,000-24,999	25,000-34,999	35,000-49,999	50,000-74,000	75,000-99,999	>99,999

How many times in the last month have you consumed lamb?	0	1	2	3	>4

Please mark a vertical line on the scale based on your opinion of the samples respective to flavor and overall acceptance.

Sample A

Extreme Dislike — **Extreme Like**

Flavor

Overall Acceptability

Willingness to Purchase

Sample B

Extreme Dislike — **Extreme Like**

Flavor

Overall Acceptability

Willingness to Purchase

Sample C

Extreme Dislike — **Extreme Like**

Flavor

Overall Acceptability

Willingness to Purchase

Sample D

Extreme Dislike — **Extreme Like**

Flavor

Overall Acceptability

Willingness to Purchase

Please rank the samples from most liked to least liked. ______ ______ ______ ______

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APPENDICES

APPENDIX A

SENSORY EVALUATION

Sensory Evaluation

1. Portions should have an internal temperature of 2-5°C before cooking. It is common to thaw portions before reheating at 2-5°C for 12-24 hours.
2. Take care and maintain sample identity throughout process.
3. Pre-heat sample holding containers and pans. Pans with separate suspended compartments can be utilized, with the addition of sand below to maintain temperature.
4. Internal temperature of each portion should be taken in the geometric center of the portion and recorded. Temperature should be in the range of 2-5°C.
5. Weigh each portion in grams before cooking and record.
6. Reheat portions until reaching an internal temperature of approximately 60°C.
7. Weight and temperature of each portion should be recorded immediately after reheating utilizing same procedures as before reheating.
8. Cut all four sides of the portion in a fashion that produces a rectangle out of the steak, while removing fat and connective tissue.
9. Cut the remaining portion into 1x2 cm pieces. Take care to attempt that all samples are devoid of fat and connective tissue.
10. Place all pieces of sample in designated sample holding container and maintain identity.
11. Panel room should be prepared before cooking to facilitate efficient panel time and minimized period after cooking until panel evaluation.
12. Panel serving and evaluations should be according to Cross et al., 1978.
13. Record all sensory data for analysis.

APPENDIX B

THIOBARBITURIC ACID (TBA) REACT SUBSTANCE ASSAY

Thiobarbituric Reactive Substance (TBA) Assay

modified from:

Buege and Aust. 1978. Methods in Ensymol. 52.302, AP

Reagents:

1. TCA/TBA stock solution: 15% TCA (w/v) and 20mM TBA (MW 144.15) reagents in DW. **Dissolve 2.88g TBA in warm DDW first, add TCA (150g) and then add DW to the mark (1L).** One liter last 100 samples in duplicate.

2. BHA: Make 10% stock solution by dissolving in 90% ethanol. Make 500ml batches.

3. TEP standard: $1 * 10^{-3}$ 1, 1, 3, 3-tetra-ethoxypropane in DW. This solution can be kept for about a week if stored in the refrigerator and diluted as needed. (MW 220.31, 95% purity, d = 0.981). Dilute 0.5 ml TEP with 499.5 ml DW, and dilute the resulting solution 1: 2.96 (TEP solution: DW) with DW.

Procedure:

1. Slice 10 g of fresh frozen meat and place in blender cup with 30 ml of DW.
2. Homogenize with a blender for 2 min. (or homogenize for 10-15 sec using a polytron at a speed 7-8.)
3. Take 2 ml of the homogenate, combine with 4 ml of the TCA/TBA reagent, 100 µl BHA, vortex thoroughly.
4. Heat the solution for 15 min in boiling water.
5. Cool for 10 min in cold water.
6. Vortex thoroughly.
7. Centrifuge at 2000G (3000RPM for 10 min).
8. Read the absorbance of the supernatant at 531 nm against a blank that contains all the reagents minus sample.

Malonaldehyde standard curves ($CHO\text{-}CH^2$, MW 72.0)

1. Construct TBA standard curve using TEP.
2. Label tubes: six tubes – 0 and two tubes of each – 5, 10, 20, 30, 40, 50
3. Add the following amount to each tube:

	TEP	DW	Set Pipettor on:
0	0 µL	2000 µL	1000 (twice)
5	10 µL	1990 µL	995 (twice)
10	20 µL	1980 µL	990 (twice)
20	40 µL	1960 µL	980 (twice)
30	60 µL	1940 µL	970 (twice)
40	80 µL	1920 µL	960 (twice)
50	100 µL	1900 µL	950 (twice)

4. Add 4 ml TBA/TCA to each tube, vortex.
5. Heat the tubes in boiling water bath for 15 min.
6. Cool in cool water bath for 20 min.
7. Vortex.
8. Read the optical density of the standard against a blank at the same wavelength (531 nm).

APPENDIX C

CONSUMER ANALYSIS

Consumer Analysis

1. Portions should reach an internal temperature of 2-5°C before cooking. It is common to thaw portions before reheating at 2-5°C for 12-24 hours.
2. Take care and maintain sample identity throughout process.
3. Reheat portions until reaching an internal temperature of approximately 60°C.
4. Cut all four sides of the portion in a fashion that produces a rectangle out of the portion, while removing fat and connective tissue.
5. Cut the remaining portion into 1x2 cm pieces. Take care to attempt that all samples are devoid of fat and connective tissue.
6. Place all pieces of sample in designated sample holding container and maintain identity.
7. Consumer first fills out demographic data including gender, ethnicity, age, household income, and the number of times they have consumed lamb within the last month.
8. Consumers then individually evaluate each of the samples for flavor, overall acceptance, and willingness to purchase.
9. To indicate opinion of each sample, consumers make a vertical line or mark on each scale. Far left signifies extremely dislike and far right signifies extremely like. No anchor points are on any of the scales.
10. Consumers then rank each sample on which was most liked to least liked.
11. To collect data, measure distance from beginning of scale to the vertical line. The middle point on the scale denotes a moderate opinion of the attribute.

Please circle the appropriate response

Gender:	Male	Female	**Ethnicity:**	White (Not Hispanic)	Black or African American	Hispanic or Latino	Asian	Pacific Islander	Native American or Alaska Native	Other
Age:	18-25	26-35	36-45	46-55	56-65	66+				
Household Income	<10,000	10,000-14,999	15,000-24,999	25,000-34,999	35,000-49,999	50,000-74,000	75,000-99,999	>99,999		
How many times in the last month have you consumed lamb?	0	1	2	3	>4					

Please mark a vertical line on the scale based on your opinion of the samples respective to flavor and overall acceptance.

Sample A

Extreme Dislike — **Flavor** — Extreme Like

Overall Acceptability

Willingness to Purchase

Sample B

Extreme Dislike — **Flavor** — Extreme Like

Overall Acceptability

Willingness to Purchase

Sample C

Extreme Dislike — **Flavor** — Extreme Like

Overall Acceptability

Willingness to Purchase

Sample D

Extreme Dislike — **Flavor** — Extreme Like

Overall Acceptability

Willingness to Purchase

Please rank the samples from most liked to least liked. _____ _____ _____ _____